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Influence of organic and inorganic fertilizers on soil fertility and productivity of wheat (*Triticum aestivum*)

DEEPENDRA KUMAR[1], SANDEEP SINGH[2], JAGPAL SINGH[3] and S P SINGH[4]

Department of Agricultural Chemistry and Soil Science, Raja Balwant Singh College, Bichpuri, Agra, Uttar Pradesh 283 105

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ABSTRACT

A field experiment was conducted at Bichpuri (Agra) during *rabi* season of 2006-07 and 2007-08 to assess the effect of organic and inorganic fertilizers on wheat (*Triticum aestivum* L.) productivity and soil fertility. The grain and straw yields of wheat increased significantly with increasing levels of NPK fertilizers up to 150% NPK. The average increase in grain and straw yield over the control was 29.7 and 32.3 and 46.2 and 56.4 % with the application of 100 and 150% NPK, respectively. There was a significant increase in uptake of nutrients by wheat crop up to 150% NPK and in Zn uptake up to 100% NPK. Integrated use of fertilizers with S and Zn increased the grain and straw yield by 32.0 and 43.4 and 35.5 and 45.5 % over control, respectively. The highest grain and straw yield was recorded with 100% NPK + 12.5 tonnes FYM/ha with a record of 46.5 and 57.7 % increase over control (28.73 and 39.87q/ha) while the application of 100% NPK + 7.5 tonnes GLM/ha (42.7 and 45.9 %) was on par with 150% NPK. The combined use of 100% NPK + 12.5 tonnes FYM/ha gave the highest net return and benefit:cost ratio. In general, fertilizer treatments including FYM proved superior to no FYM in respect of yield of protein. The maximum uptake of NPK by the crop was noted with 150% NPK which was statistically at par with 100% NPK + 12.5 tonnes FYM/ha and those of S and Zn with 100% NPK + 20 kg S/ha and 100% NPK + 5 kg Zn/ha, respectively. Integrated use of FYM with mineral fertilizers improved the organic carbon status and available N, P, K, S and Zn in soil thereby, sustaining the soil health. The omission of S and Zn in fertilizer schedule caused a depletion in the available S and Zn status of soil.

Key words: Inorganic fertilizers, Organic manure, Productivity, Soil fertility, Wheat

Wheat (*Triticum aestivum* L.) is one of the most important staple food grain crops cultivated next to rice, both in area and production but it stands first in productivity amongst the cereals. Stagnation in wheat production, lower productivity and inferior quality of the produce is due to various constraints including inadequate and imbalanced nutrient application (Prasad 2012). Therefore, adequate and balanced fertilization is necessary to increase the wheat productivity. The use of organic manures improves soil physical, chemical and biological property, fertilizer use efficiency, mitigates short supply of micronutrients and plays an important role in the maintenance of soil fertility and improves the ecological balance of rhizosphere. Use of a chemical fertilizer or organic manure alone cannot achieve and sustain the desired level of crop production under intensive cropping. Conjoint use of organic manures and chemical fertilizers is very essential as this not only sustains higher level of productivity but also improves soil health and enhances the nutrient use efficiency. Sulphur is involved in the formation of chlorophyll. It improves root growth, crop yield, seed formation, plant protein, cereal quality for baking and nutritional quality of crop. Zinc deficiency is a common problem in wheat and other cereals. About 50% of soils used for cereal production in the world have low levels of plant available Zn (Graham and Welch 1996). Wheat shows substantial decrease in growth and grain yield under Zn deficient field conditions (Graham *et al.* 1992, Cakmak *et al.* 1996). Of late, there has been a growing concern of cultivating crops under integrated management of nutrients because of the escalating cost of inorganic fertilizers, declining soil fertility status and degrading environment and soil health due to pesticide usage (Ramesh *et al.* 2005). The present experiment was undertaken to study the effect of application of plant nutrients either singly or in combination with or without organic manures on nutrient uptake and productivity of wheat on sandy loam soil of Agra.

[2]SMS (Soils), KVK, RBS College, Bichpuri, Agra, Uttar Pradesh 283 105; [4]CTO (e mail: spsingh_edu@yahoo.com), ICAR HQ, New Delhi 110 012

MATERIALS AND METHODS

The field experiment was conducted at the Research farm of Raja Balwant Singh College, Bichpuri, Agra (UP) during *rabi* season of 2006-07 and 2007-08. The

geographical position of the experimental site is 27° 22' laltitude and 77° 9' longitude. The experimental soil contained 3.5 g/kg organic carbon, 169 kg available N, 8.1 kg/ha available P, 126 kg/ha available K, 0.55 mg/kg DTPA-Zn and 8.2 mg/kg available S. The experiment consisted of 11 treatments, viz.; T_1, control; T_2, 100% N; T_3, 100% N P; T_4, 100% NPK; T_5, 100% NPK + 5 kg Zn / ha; T_6, 100% NPK + 20 kg S / ha; T_7, 100% NPK 12.5 tonnes FYM / ha; T_8, 100% NPK + 7.5 tonnes GLM / ha; T_9 12.5 tonnes FYM/ha; T_{10}, 7.5 tonnes GLM / ha and T_{11}, 150% NPK was laid out in randomized block design with 3 replications. Wheat was sown on November 10 in both the years at 20 cm spacing. The 100% recommended dose of NPK for wheat (120, 60 and 40 kg/ha) was applied through urea, diammonium phosphate and muriate of potash, respectively. The whole P_2O_5 and K_2O and half nitrogen were applied at the time of sowing. Remaining nitrogen was applied by splitting in to two equal parts at 30 and 60 days after sowing. The S and Zn were applied as elemental sulphur and zinc chloride, respectively at the time of sowing. Well decomposed FYM (0.65% N, 0.25% P and 2.06% K) and dry green leaf manure (2.15% N, 0.26% P and 2.06% K) were applied to plots as per treatments 15 days before sowing. Rest of the management practices were in accordance with the recommended package of practices for the crop. Harvesting of the wheat was done in second week of the April in both the years. The grain and straw samples of wheat were analysed for their N content by Kjeldahi method. Phosphorus, K, S and Zn in the di acid digest (HNO_3: $HCIO_4$) were determined by vanado molybdate yellow colour method (Jackson 1973), flame photometer, turbidi metric method and atomic absorption spectrophotometer, respectively. Soil samples collected after harvest of the crop were analysed for different parameters by following standard procedures for organic carbon (wet digestion method), available N (alkaline permanganate method), available P (Olsen method), available K (ammonium acetate extract), available S (Chesnin and Yien 1951) and DTPA-Zn (Lindsay and Norvell, 1978).

RESULTS AND DISCUSSION

Grain and straw yield

Pooled data showed significant increase in grain and straw yields of wheat (Table 1) due to application of 100% N and 100% NP on control. The response of wheat to N and P may be attributed to exhaustive nature of the crop removing more nutrients and thus resulting response to those of nitrogen and phosphorus. Similar results have been reported by Verma *et al.* (2005). Increased levels of chemical fertilizers (100 to 150% NPK) increased grain and straw yield significantly by 29.7 and 32.3 and 46.2 and 56.4%, respectively over control. Kumar *et al.* (2011) also reported similar results. Combined use of FYM, S and Zn with chemical fertilizers (100% NPK) also increased the grain and straw yield of wheat. The mean increases in grain and straw yields with 100% NPK + 5 kg Zn/ha and 100% NPK + 20 kg S/ha over control were 35.5 and 45.5 and 32.4 and 43.4%, respectively. The beneficial effect of Zn and S may be due to their contribution in supplying Zn and S to the deficient soil (Singh *et al.* 2006, Kumar *et al.* 2011). Application of 100% NPK + 12.5 tonnes FYM/ha gave the maximum grain and straw yields which were 46.5 and 57.7% higher over the control, respectively. The higher yield under integrated use of organics with NPK fertilizers may be ascribed to balanced use of essential nutrients besides improvement in soil health. The yields of wheat grain and straw with 100% NPK + 12.5 tonnes FYM/ha did not differ significantly than those obtained with 100% NPK + 7.5 tonnes GLM/ha and 150% NPK indicating the possibility of harnessing the values at the cost of 50% NPK in the form of chemical fertilizers. The role of balanced fertilization in wheat yield is well documented (Singh 2006). Application of 100% NPK was superior to 100% N or 100% NP in influencing the yield of grain. Application of 12.5 tonnes FYM and 7.5 tonnes GLM/ha also increased the grain and straw yield over control by 19.3 and 17.6 and

Table 1 Effect of organic and inorganic fertilizers on yield, protein content and economics of wheat (mean data of 2 years)

Treatment	Yield (t/ha)		Protein content (%)		Protein yield	Net return	B:C ratio
	Grain	Straw	Grain	Straw	(kg/ha)	(₹/ha)	
T_1 Control	2.87	3.99	11.93	3.37	357.3	18 894.5	1.39
T_2 100% N	3.33	4.38	13.03	4.12	433.7	22 173.0	1.49
T_3 100% NP	3.49	4.71	12.74	4.21	444.6	22 980.0	1.43
T_4 100% NPK	3.70	5.28	13.02	4.30	481.7	25 460.0	1.54
T_5 100% NPK + 5 kg Zn/ha	3.89	5.80	13.37	4.37	520.3	27 521.0	1.60
T_6 100% NPK + 20 kg S/ha	3.79	5.72	13.46	4.27	510.7	26 636.5	1.56
T_7 100% NPK + 12.5t FYM /ha	4.21	6.29	13.74	4.52	578.3	30 111.0	1.66
$T_8$100% NPK +7.5t GLM/ ha	4.10	5.94	13.65	4.68	559.7	27 555.0	1.43
T_9 12.5 t FYM/ha	3.43	4.69	12.43	4.12	426.2	23 141.0	1.50
T_{10} 7.5 t GLM/ha	3.43	4.66	12.84	4.21	440.0	22 319.0	1.38
T_{11} 150% NPK	4.20	6.24	14.84	4.77	623.3	29 925.0	1.62
SEm ±	0.07	0.06	0.11	0.04	7.54		
CD (P=0.05)	0.15	0.12	0.22	0.09	15.25		

GLM, Green leaf (Sunnhemp) manure (dry)

Table 2 Effect of various treatments on N, P, K .S (kg/ha) and zinc (g/ha) uptake in wheat (mean data of 2 years)

Treatment	Nitrogen		Phosphorus		Potassium		Sulphur		Zinc	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
T_1 Control	54.8	21.5	5.6	3.9	13.4	86.3	5.2	5.3	84.6	88.4
T_2 100% N	69.4	27.8	6.8	5.8	16.9	93.2	6.3	5.6	98.7	92.6
T_3 100% NP	71.1	30.4	8.1	6.0	18.6	100.6	6.9	6.5	103.5	98.5
T_4 100% NPK	77.2	36.6	8.7	7.1	21.6	125.3	7.9	7.6	108.6	115.0
T_5 100% NPK + 5 kg Zn/ha	83.2	40.6	8.3	7.2	22.3	135.2	7.9	7.8	133.6	156.0
T_6 100% NPK + 20 kg S/ha	81.7	39.2	8.9	7.7	22.1	133.8	9.8	10.6	114.0	126.6
T_7 100% NPK + 12.5 t FYM /ha	92.5	45.5	10.7	9.7	26.5	153.2	10.3	10.4	134.5	144.0
$T_8$100% NPK +7.5 t GLM/ ha	89.5	44.4	10.4	9.1	25.4	146.1	9.6	8.8	132.5	137.5
T_9 12.5 t FYM/ha	68.2	30.9	7.3	6.3	18.0	114.9	7.5	7.0	108.3	105.6
T_{10} 7.5 t GLM/ha	70.4	31.4	7.7	5.8	18.2	121.1	7.3	7.6	108.4	104.8
T_{11} 150% NPK	99.7	47.7	11.3	9.6	27.1	158.1	9.4	10.9	124.7	137.6
SEm ±	3.3	2.7	1.04	0.87	1.77	4.29	0.29	0.30	3.60	3.59
CD (P=0.05)	6.8	5.5	2.09	1.80	3.57	8.66	0.60	0.62	7.27	7.25

19.2 and 16.9 percent, respectively. Among the nutrient sources, maximum net returns (₹ 30 111/ha) and B:C ratio (1.66) were recorded with 100% NPK + 12.5 tonnes FYM /ha closely followed by 150% NPK (₹ 29 925/ha). This trend in economic returns is mainly owing to the treatments effects on the grain and straw yield.

Protein

The lowest content and yield of protein were recorded in control, which may be attributed to low nitrogen status of the soil. Application of 100% N and 100% NP resulted in significant increase in protein content and yield over control. Both the levels of NPK (100 and 150%) increased the protein content and yield significantly over control. Protein content and yield also improved when 100% NPK was added in combination of 5 kg Zn/ha or 20 kg S/ha. The magnitude of increase was higher with sulphur as compared to zinc. The highest values of protein content and yield were noted under 100% NPK + 12.5 tonnes FYM/ha. The increased N content in grain resulted in higher protein content due to integrated use of NPK fertilizer and FYM or GLM. The higher protein production might be due to more grain yield as well as increased protein content in the grain (Dudhat *et al.* 1997).

Uptake of nutrients

The uptake of nutrients by wheat crop differed significantly due to various treatments and lowest uptake of all the nutrients was noted in control (Table 2). The uptake of N, P and K increased progressively with increasing in rates of their application and significantly higher total uptake of N (174.4 kg/ha), P (20.9 kg/ha) and K (185.2 kg/ha) was recorded with 150% NPK. It was due to the fact that added nutrients increased the N, P and K content in wheat by providing balanced nutritional environment inside the plant and higher photosynthetic efficiency, which favoured higher yield, resulted in more uptake of N, P and K by wheat. The uptake of S and Zn was maximum with 100% NPK + 20 kg S/ha and 100% NPK + 5 kg Zn/ha, respectively. Kumar *et al.* (2011) also reported an increase in S and Zn uptake with their addition. Application of 12.5 tonnes FYM/ha and 7.5 tonnes GLM/ha significantly increased the uptake of nutrients by wheat over control. The increase in uptake of nutrients with FYM and GLM was due to increase in availability of nutrients to the plants. Mean nitrogen uptake by wheat grain and straw increased from 54.8 to 92.5 and 21.5 to 45.5 kg/ha with the application of 100% NPK + 12.5 tonnes FYM/ha. Increase in N uptake with integrated use of FYM or GLM and mineral fertilizers might be due to release of N as a result of decomposition of FYM and GLM. Addition of FYM and GLM also increased the microbial population, which resulted in the enhanced availability of nitrogen. Phosphorus and K uptake by wheat grain and straw also increased significantly with 100% NPK + 12.5 tonnes FYM/ha over control. This increase in P uptake may be ascribed to more availability of P from the added fertilizers and also to the solubilizing action of organic acids produced during decomposition of FYM. The increase in K uptake may be due to the release of K from the K-bearing minerals by complexing agents. Higher uptake of all the five nutrients (N, P, K, S and Zn) due to combined application of organic manures and fertilizers might have resulted in higher yields. Similar observations were reported by Singh (2006) and Rathod *et al.* (2012).

Soil fertility

The organic carbon content of the soil increased from initial status of 3.5 g/kg to 4.4 g/kg with the application of 100% NPK + 12.5 tonnes FYM/ha. Singh *et al.* (2006) reported similar improvement in organic carbon content in soil with the combined use of organic and inorganic fertilizers. However, application of 150% NPK fertilizer slightly improved the organic carbon content due to rapid mineralization and absence of formation of organic mineral complexes (Tiwari *et al.* 2002). Increasing levels of NPK (100 to 150%) significantly enhanced the amounts of

Table 3 Effect of various treatments on organic carbon and available nutrients in post harvest soil (mean data of 2 years)

Treatment	Org. C (g/kg)	Nitrogen (kg/ha)	Phosphorus (kg/ha)	Potassium (kg/ha)	Sulphur (mg/kg)	Zinc (mg/kg)
T_1 Control	3.1	143.1	7.2	114.0	7.8	0.53
T_2 100% N	3.2	160.4	7.0	106.5	7.7	0.52
T_3 100% NP	3.4	163.7	9.4	102.0	7.5	0.50
T_4 100% NPK	3.5	165.0	9.9	136.2	7.5	0.50
T_5 100% NPK + 5 kg Zn/ha	3.5	166.0	10.0	133.3	8.1	0.71
T_6 100% NPK + 20 kg S/ha	3.6	165.0	10.5	134.0	9.0	0.53
T_7 100% NPK + 12.5t FYM /ha	4.4	175.8	12.0	153.0	8.5	0.68
$T_8$100% NPK +7.5t GLM/ ha	4.1	175.2	11.8	151.0	8.5	0.63
T_9 12.5 t FYM/ha	4.2	166.6	10.4	140.0	8.4	0.66
T_{10} 7.5 t GLM/ha	4.2	166.6	9.9	138.0	8.4	0.60
T_{11} 150% NPK	3.7	170.0	11.7	151.0	8.0	0.50
SEm ±	0.07	1.35	0.16	2.56	0.13	0.01
CD (P=0.05)	0.16	2.80	0.33	5.32	0.27	0.07

available N, P and K over control (Tiwari *et al.* 2002). It was due to addition of adequate amounts of N, P and K through higher level of fertilizers. Integrated nutrient management significantly increased the available N, P, K, S and Zn in soil compared to initial values, whereas in the control plots they declined significantly. A significant reduction in available P content under 100% N alone occurred due to removal of P by the crop. Similar trend on available P status of soil has been reported by Verma *et al.* (2005). The highest available nutrients (available N 178.8 kg/ha, P 12.0 kg/ha and K 153.0 kg/ha) were recorded with 100% NPK + 12.5 tonnes FYM/ha indicating the benefits from the integrated use of fertilizers and manures which is also evident from the yield data. The increased available P content of soil might be due to release of CO_2 and organic acids during decomposition, which helps in solubilizing the native soil P. The beneficial effect of FYM on available K status may be ascribed to the reduction in K-fixation due to the interaction of organic matter with clay besides the direct K addition to the K pool of the soil. Similar results were reported by Kumar *et al.* (2012). FYM and GLM alone or in combination with 100% NPK significantly increased the Zn content over 100% NPK. The maximum value of available S (9.0 mg/kg) and Zn (0.68 mg/kg) were recorded with 100% NPK + 20 kg S/ha and 100% NPK + 5 kg Zn/ha, respectively. Kumar *et al*. (2011) and Rathod *et al.* (2012) also reported an increase in available S and Zn status of soil with their application. The increase in buildup of available nutrients might have attributed to maximum left over of nutrients in the soil due to application of various treatments. Singh *et al.* (2006) reported that available nutrients improved in integrated nutrient management practices. The magnitude of addition of nutrients with the FYM was more as compared to inorganic sources where nutrients were gradually available in the soil.

CONCLUSION

Based on these results, it can be concluded that increasing levels of NPK fertilizers increased the crop yields, uptake of nutrients and status of available nutrients in soils. The combined use of 100% NPK + 12.5 tonnes FYM/ha was found to be beneficial in increasing the productivity of wheat and improving soil fertility status as compared to sole application of 100% NPK. The uptake of nutrients was higher in FYM along with NPK fertilizers. Green leaf manure was less effective than decomposed FYM. Further, the importance of inclusion of S and Zn in fertilizer schedule is also highlighted by these results as treatments devoid of S and Zn did not exhibit deleterious effect on available S and Zn status of soil as well as crop productivity.

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